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Title: (U) LNK3DNT Capability in SENSMG Tested with Transport Correction

Author(s): Favorite, Jeffrey A.

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Los Alamos
NATIONAL LABORATORY
memorandum
X-Computational Physics Division
Radiation Transport Applications Group
Group XCP-7, MS F663
Los Alamos, New Mexico 87545
505/667-1920

To/MS: Distribution
From/MS: Jeffrey A. Favorite / XCP-3, MS F663
Phone/Email: 7-7941 / fave@lanl.gov
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SUBJECT: (U) LNK3DNT Capability in SENSMG Tested with Transport Correction

I. Introduction

The SENSMG multigroup neutron sensitivity code[1,2] can read materials and geometry from `redoin` and `lnk3dnt` files written by the PARTISN multigroup discrete ordinates code[3] or the MCNP6 Monte Carlo code.[4] Reference 5 described an initial version of this capability. Reference 6 introduced two important extensions: 1) Reaction-rate ratios are now allowed as responses with `redoin`/`lnk3dnt` inputs; and 2) Sensitivities of reaction-rate ratios to mass densities and interface locations are now calculated (for all problems, not just `redoin`/`lnk3dnt` problems).

In this report, we document the testing of the `redoin`/`lnk3dnt` capability when used with transport correction. PARTISN's transport corrections are described in Ref. 3, and Refs. 7 and 8 discuss the calculation of cross-section sensitivities when transport corrections are applied. References 7 and 8 verify SENSMG for problems with transport correction using central differences. This report verifies the capability with `redoin`/`lnk3dnt` inputs by comparison with regular SENSMG inputs. Unlike Refs. 5 and 6, in this report we use a spherical test problem because the sensitivity of the response with respect to the highest-order scattering is zero in cylinders due to the use of flux moments in the inner products.[7]

Not all of the capability of SENSMG is available for `redoin`/`lnk3dnt` inputs. The only responses allowed are k_{eff} or α eigenvalues and reaction-rate ratios in eigenvalue problems. Fixed-source problems are not allowed.

The next section of this report describes the verification of the capability when used with diagonal transport correction.[3,7,8] Section III is a summary and conclusions. The input files used for verification are listed in the appendix.

II. Verification

II.A.1. Test Problem

A one-dimensional spherical problem with two materials was used for verification. The geometry is a simplified version of the BeRP ball reflected with polyethylene.[9] The materials are defined in Table I and dimensions are shown in Figure 1. The α-Pu of Table I is a simplification of the material specification given in Ref. 9 in which the impurities were replaced with natural gallium.

Table I. Materials in the Test Problem.

Index	Material	Composition (Weight Fraction)	Density (g/cm^3)
1	α-Pu	^{239}Pu 9.38039E-01; ^{240}Pu 5.94112E-02; ^{69}Ga 1.51515E-03; ^{71}Ga 1.03465E-03	19.6
2	Polyethylene	C (nat.) 8.56299E-01; ^{1}H 1.43701E-01	0.95

This experiment measured neutron and gamma-ray leakage and subcritical multiplication in Ref. 9. Here we use the system's k_{eff}, which is not physically meaningful, as the response, and we intentionally don't converge the transport solution very tightly. Differences in calculations should be magnified. We also compute two reaction-rate ratios in the plutonium region shown on Figure 1. The two reaction-rate ratios are the fission rate in Pu-239 (not really a ratio) and the ratio of the elastic scattering rate in Ga-69 to the fission rate in Pu-239.

PARTISN version 8.31.37 was used. All input files were run with S_{32} quadrature, P_1 scattering with diagonal transport correction, and a convergence criterion (PARTISN's `epsi`) of 1E-3. These parameters were set on the input line. The test problems used 24 processors. Multisweep was turned off[10] by setting extras(48)=1 in order to preserve repeatability.

SENSMG's new `redoin`/`lnk3dnt` capability was verified by ensuring that the sensitivities computed using it are identical to those computed using a regular SENSMG input (as defined in Refs. 1 and 2).

II.A.2. Procedure for Test 1

Results of the `redoin`/`lnk3dnt` capability were compared with those from a regular SENSMG input that specified the problem as normal, with materials defined in coarse meshes as shown in Figure 1. The `redoin` and `lnk3dnt` files written by PARTISN from the regular SENSMG input were used. Sensitivities from both inputs should be identical.

The procedure was as follows:
1. Run the initial, regular SENSMG input file to completion. Save all output.
2. Save the `redoin` file from the `for` directory and modify it as follows:
    a. Remove the entries in "`&block_2`" (leaving "`&block_2`").
    b. Remove the entries in "`&block_2_arrays`" (leaving "`&block_2_arrays`").
    c. In "`&block_6`", add the lines "`/ nrrr=2`" and "`points_size=1`".
    d. In "`&block_6_arrays`", delete the `edmats` and `edxs` arrays.
    e. In "`&block_6_arrays`", add the `edisos`, `edxs`, and `points` arrays from the appendix.

Note that the resulting file is not a legitimate PARTISN input file, but it is good enough because SENSMG reads it and constructs from it a legitimate PARTISN input file.

3. Run the forward PARTISN input file associated with the original SENSMG run and write a `lnk3dnt` file from it by adding "`wrlnk3d=1`" to block 5. Save the new `lnk3dnt` file.
4. Run to completion SENSMG with the `redoin` file modified in step 2 and the `lnk3dnt` file created in step 3.
5. Compare the cross section sensitivities in `sens_k_x` from steps 1 and 4. They should be identical.
6. Compare the cross section sensitivities in `sens_rr_x` from steps 1 and 4. They should be identical.
7. Compare the mass density sensitivities and surface derivatives in `sens_k_r` from steps 1 and 4. They should be identical.
8. Compare the mass density sensitivities and surface derivatives in `sens_rr_r` from steps 1 and 4. They should be identical.

In this procedure, there were two input files run in SENSMG.

The input file run in step 1 is listed in the appendix. The `redoin` file as modified in step 2 is listed in the appendix.

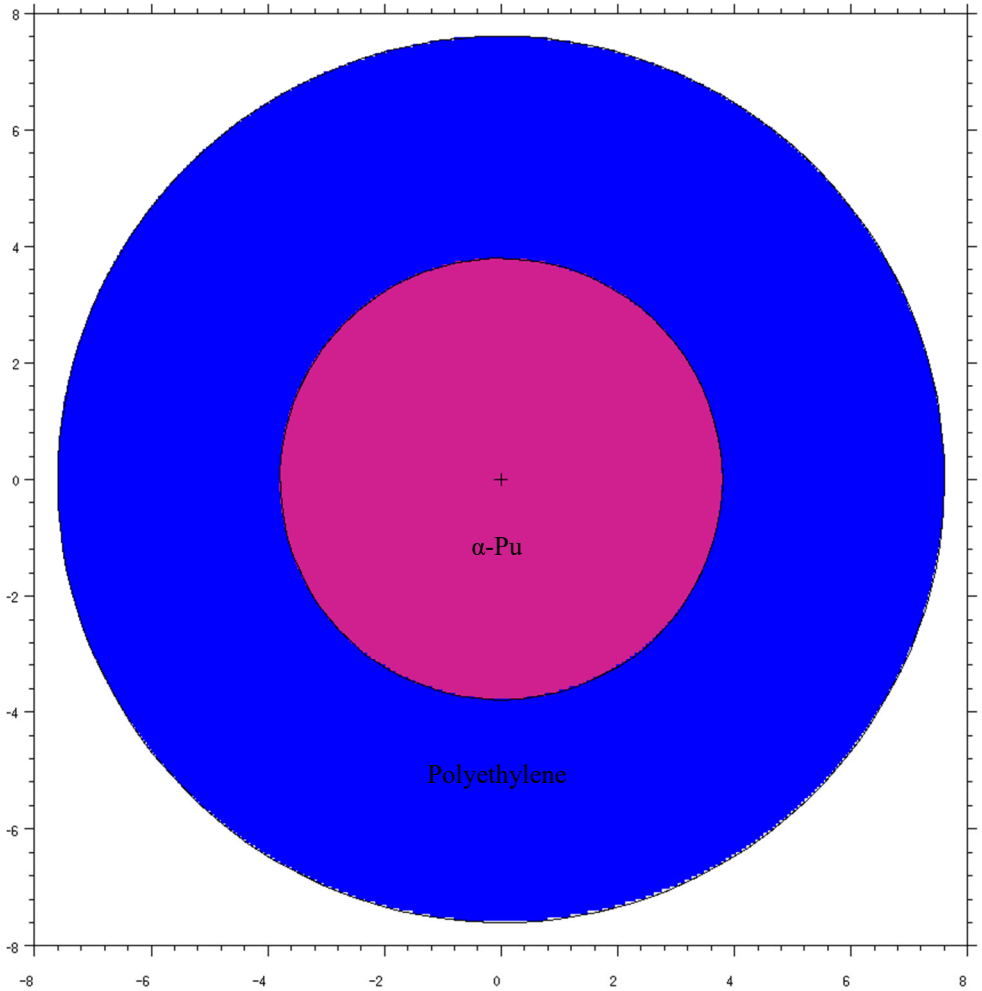

Figure 1. Cross-section of the spherical geometry. Scales in centimeters.

II.A.3. Results for Test 1

Both input files gave exactly the same k_{eff}, 0.88580968, and identical values for the two reaction-rate ratios.

Comparing the k_{eff} cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 5), they are identical.

Comparing the reaction-rate ratio cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 6), they are identical.

Comparing the k_{eff} mass density sensitivities and surface derivatives from the regular SENSMG input and the `redoin/lnk3dnt` input (step 7), they are identical.

Comparing the reaction-rate ratio mass density sensitivities and surface derivatives from the regular SENSMG input and the `redoin/lnk3dnt` input (step 8), they are identical.

II.A.4. Procedure for Test 2

Results of the `redoin/lnk3dnt` capability generated from MCNP6.2 were compared with those from a regular SENSMG input that specified the problem as normal. The MCNP6.2 mesh was spherical and had 10 fine meshes in the radial direction (MCNP6's `lnk3dnt` file sets the number of coarse meshes to the number of fine meshes). The fine meshes are shown in Figure 2. Comparing Figure 2 with Figure 1 shows that the mesh in this test causes materials to mix in the fifth mesh from the center, 3.0416 cm < r < 3.8020 cm. The regular SENSMG input used the mesh of Figure 2. Reaction-rate ratios were computed in the first five meshes from the center. Sensitivities from both inputs should be identical.

The procedure was as follows:

1. Run the MCNP6 input file listed in the appendix using MCNP6's "im" execution options to write a PARTISN input file and `lnk3dnt` file. Save the files.
2. Modify the PARTISN input file created in step 1 as follows:
    a. In block 1, change `mt` from 2 to 4 (the number of materials in the problem plus the number of edit nuclides).
    b. Replace all of block 4 with the material compositions defined by weight fraction, using unity for the mass densities on the `assign` keyword (this is not necessary in general; these tests were all done on a mass-density basis). Append the two edit isotopes as materials 3 and 4 with density 1 on the `matls` keyword. Append two entries of `atdens` on the `matspec` keyword.
    c. In block 5, add "`nofxup=1 iitl=0`". These keywords are not recognized by MCNP6 (but they should be).
3. Run the PARTISN input file created in step 2. Save the resulting `redoin` file.
4. Modify the redoin file created in step 3 as follows:
    a. In "`&block_6`", add the lines "`/ nrrr=2`" and "`points_size=5`".
    b. In "`&block_6_arrays`", add the `edisos`, `edxs`, and `points` arrays from the appendix.
5. Run to completion SENSMG with the `redoin` file modified in step 4 and the `lnk3dnt` file created in step 1. Save all output.

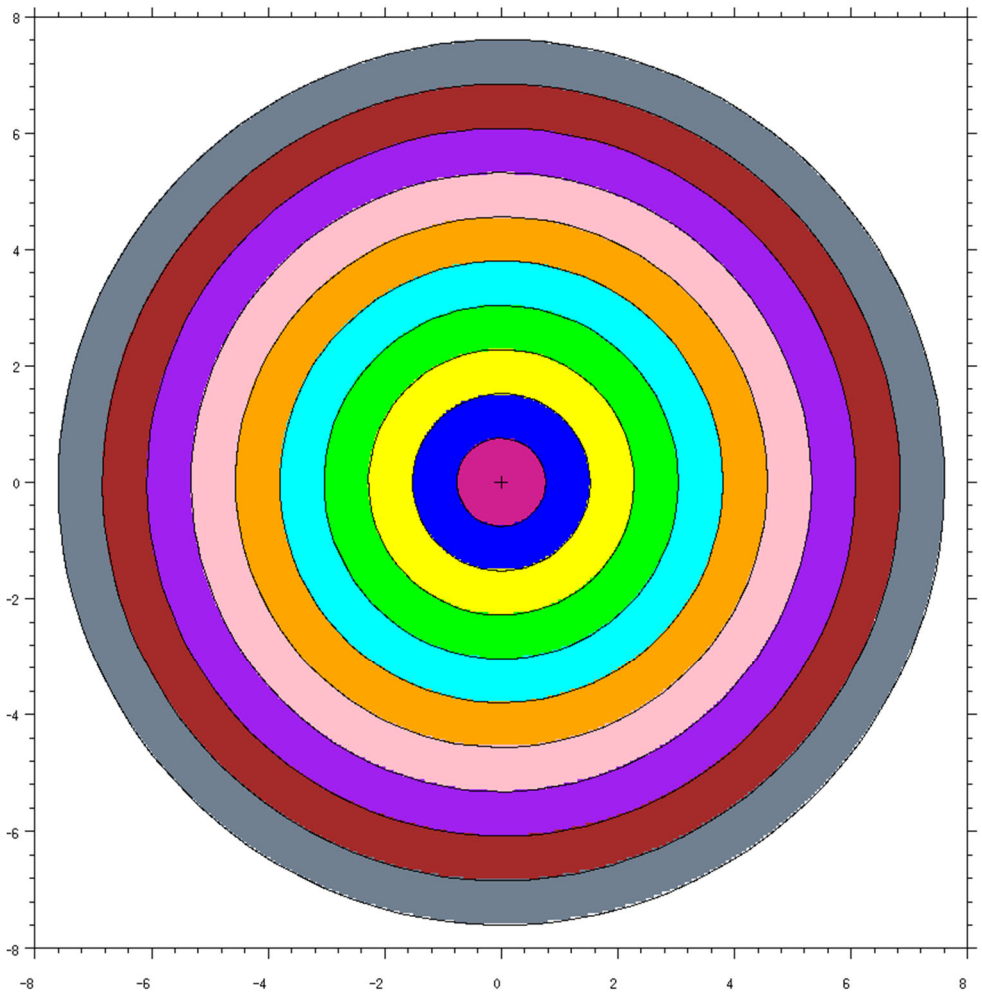

Figure 2. Cross-section of the MCNP6 `lnk3dnt` spherical geometry. Scales in centimeters.

6. Run SENSMG with the `redoin` file modified in step 4 and the `lnk3dnt` file created in step 1 and write a regular SENSMG input file from its data using "`-wrsensmg yes`" on the command line. The new SENSMG input file is called `tmp_sensmg_inp`. Save it.
7. Run to completion SENSMG with the input file created in step 6. Save all output.
8. Compare the cross section sensitivities in `sens_k_x` from steps 5 and 7. They should be identical.
9. Compare the cross section sensitivities in `sens_rr_x` from steps 5 and 7. They should be identical.
10. Compare the mass density sensitivities and surface derivatives in `sens_k_r` from steps 5 and 7. They should be identical.
11. Compare the mass density sensitivities and surface derivatives in `sens_rr_r` from steps 5 and 7. They should be identical.

In this procedure, there were two input files run in SENSMG. The MCNP6 input file run in step 1 (and plotted in Figure 1) is listed in the appendix. The PARTISN input file run in step 3 is listed in the appendix. The regular SENSMG input file created in step 6 is listed in the appendix. It was run with 1 fine mesh in each coarse mesh in each direction, which was set by modifying the source code for this test.

II.A.5. Results for Test 2

Both input files gave exactly the same k_{eff}, 0.87753468, and identical values for the three reaction-rate ratios. Most of the sensitivities were identical.

Comparing the k_{eff} cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 8), 24 differ in the sixth digit after the decimal. This is out of 6918 non-zero values compared. The comparison uses the isotope totals because the `redoin/lnk3dnt` capability only computes isotope totals, rather than sensitivities of isotopes in each mesh.

Comparing the reaction-rate ratio cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 9), 32 differ in the sixth digit after the decimal. This is out of 13,836 non-zero values compared. The comparison uses the isotope totals because the `redoin/lnk3dnt` capability only computes isotope totals, rather than sensitivities of isotopes in each mesh.

Comparing the k_{eff} mass density sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 10), three differ in the sixth digit after the decimal. This is out of 300 non-zero values compared.

Comparing the k_{eff} surface derivatives from the regular SENSMG input and the `redoin/lnk3dnt` input (step 10), one small value ($\sim -10^{-7}$) differs in the fifth digit after the decimal, and three values differ in the sixth digit. This is out of 90 non-zero values compared.

Comparing the reaction-rate ratio mass density sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 11), they are identical. Six hundred non-zero values were compared.

Comparing the reaction-rate ratio surface derivatives from the regular SENSMG input and the `redoin/lnk3dnt` input (step 11), two values differ in the sixth digit after the decimal. This is out of 180 non-zero values compared.

Because MCNP6 mixes materials in a mesh by random sampling,[4] it does not write consistent densities to the `lnkout` file. Even when the mesh was set up to align with the material interfaces (so that no materials are mixed), the same material appeared at various densities. The formula for the adjoint-based derivative of a response with respect to an interface location involves differences of macroscopic cross sections across the interface.[1] Therefore, the `redoin/lnk3dnt` input from MCNP6 results in many nonzero derivatives that should be zero and are zero with the regular SENSMG input. These nonzero values are very small: none is greater in magnitude than 2×10^{-13}.

II.A.6. Procedure for Test 3

Finally, the capability was tested with a `redoin/lnk3dnt` setup that defined a separate material in each fine mesh of the PARTISN input for the original input from Test 1 (Sec. II.A.2). SENSMG uses a default fine mesh spacing of 0.005 cm for spheres, so there were 1521 fine meshes, 759 in the plutonium and 762 in the polyethylene. The `lnk3dnt` file for this geometry was written with an auxiliary code according to the file format given in Ref. 3. Results were compared with those from a regular SENSMG input that specified the problem as normal, with materials defined in coarse meshes as shown in Figure 1, and a regular but finely-discretized SENSMG input that specified the problem using the same mesh

that the `redoin`/`lnk3dnt` capability sets up. Reaction-rate ratios were computed in the meshes containing plutonium. Sensitivities from the three inputs should be identical.

The procedure was as follows:

1. Run the initial, regular SENSMG input file to completion. Save all output.
2. Save the `redoin` file and modify it as follows:
    a. In block_1, change `im` from 2 to 1521 (the number of fine meshes).
    b. In block_1, change `mt` from 4 to 8 (the number of nuclides in the problem, including the edit nuclides).
    c. In block_1, change `nzone` from 2 to 8 (the new `mt`).
    d. Remove the entries in "`&block_2`" (leaving "`&block_2`").
    e. Remove the entries in "`&block_2_arrays`" (leaving "`&block_2_arrays`").
    f. In block_4_arrays, change `matspec` to `matspec="atdens"` (including the quotation marks; see appendix for format).
    g. In block_4_arrays, change `assign` to `assign="matls"` (including the quotation marks; see appendix for format).
    h. In block_4_arrays, change `matls` to list each nuclide with an atom density of 1., including the edit nuclides (see the appendix for format).
    i. In "`&block_6`", add the lines "`/ nrrr=2`" and "`points_size=759`".
    j. In "`&block_6_arrays`", delete the `edmats` and `edxs` arrays.
    k. In "`&block_6_arrays`", add the `edisos`, `edxs`, and `points` arrays from the appendix.

    Note that the resulting file is not a legitimate PARTISN input file, but it is good enough because. SENSMG reads it and constructs from it a legitimate PARTISN input file.
3. Run the original SENSMG file and write a `lnk3dnt` file from its data using subroutine wrdantlnk called from the main program, sensmg. The new `lnk3dnt` file is called `tmp_lnk3dnt`. Save it.
4. Run to completion SENSMG with the `redoin` file modified in step 2 and the `lnk3dnt` file created in step 3.
5. Compare the cross section sensitivities in `sens_k_x` from steps 1 and 4. They should be identical.
6. Compare the cross section sensitivities in `sens_rr_x` from steps 1 and 4. They should be identical.
7. Compare the mass density sensitivities and the surface derivatives in `sens_k_r` from steps 1 and 4. They should be identical.
8. Compare the mass density sensitivities and the surface derivatives in `sens_rr_r` from steps 1 and 4. They should be identical.
9. Run the `redoin` file modified in step 2 and the `lnk3dnt` file created in step 3 and write a new, finely-discretized SENSMG input file using "`-wrsensmg yes`" on the command line. The new SENSMG input file is called `tmp_sensmg_inp`. Save it.
10. Run to completion SENSMG with the SENSMG input file created in step 9.
11. Compare the cross section sensitivities in `sens_k_x` from steps 4 and 10. They should be identical.
12. Compare the cross section sensitivities in `sens_rr_x` from steps 4 and 10. They should be identical.
13. Compare the mass density sensitivities and surface derivatives in `sens_k_r` from steps 4 and 10. They should be identical.

14. Compare the mass density sensitivities and surface derivatives in `sens_rr_r` from steps 4 and 10. They should be identical.

In this procedure, there were three input files run in SENSMG. The input file run in step 1 is the same as that run in step 1 of Sec. II.A.2. It is listed in the appendix. The `redoin` file as modified in step 2 is listed in the appendix.

The finely-discretized SENSMG input file created in step 9 is 1535 lines long (there is, for example, one line for each material[2]) and is not listed in the appendix. It specified materials by weight fraction and mass density (using a switch in the source code). It was run using 1 fine mesh in each coarse mesh in each direction, again by modifying the source code for this test.

II.A.7. Results for Test 3

All three input files gave exactly the same k_{eff}, 0.88580968, and identical values for the two reaction-rate ratios. Most of the sensitivities were identical.

Comparing the k_{eff} cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 5), they are identical except for differences in the sum of the chi sensitivities that are supposed to be zero but are numerically only very small (e.g. 10^{-17}). The individual group components of the chi sensitivities are all identical. The comparison uses the isotope totals because the `redoin/lnk3dnt` capability only computes isotope totals, rather than sensitivities of isotopes in each mesh.

Comparing the reaction-rate ratio cross-section sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 6), they are identical except for differences in the sum of the chi sensitivities that are supposed to be zero but are numerically only very small (e.g. 9E-17). The individual group components of the chi sensitivities are all identical. The comparison uses the isotope totals because the `redoin/lnk3dnt` capability only computes isotope totals, rather than sensitivities of isotopes in each mesh.

Comparing the k_{eff} mass density sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 7), they are almost identical. Two values (out of 60 compared) differ in the sixth digit after the decimal. This comparison required summing the appropriate `redoin/lnk3dnt` sensitivities to match the fine meshes with the corresponding coarse meshes on Figure 1.

Comparing the k_{eff} surface derivatives for the material interfaces and outer boundary from the regular SENSMG input and the `redoin/lnk3dnt` input (step 7), they are identical.

Comparing the reaction-rate ratio mass density sensitivities from the regular SENSMG input and the `redoin/lnk3dnt` input (step 8), three values (out of 120 compared) differ in the sixth digit after the decimal. This comparison required summing the appropriate `redoin/lnk3dnt` sensitivities to match the fine meshes with the corresponding coarse meshes on Figure 1.

Comparing the reaction-rate ratio surface derivatives for the material interfaces and outer boundary from the regular SENSMG input and the `redoin/lnk3dnt` input (step 8), they are identical.

Comparing the k_{eff} cross-section sensitivities from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 11), two values differ in the fifth digit after the decimal and 51 differ in the sixth. This is out of 6738 non-zero values compared.

Comparing the reaction-rate ratio cross-section sensitivities from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 12), 55 values differ in the sixth digit after the decimal. This is out of 13,476 non-zero values compared.

Comparing the k_{eff} mass density sensitivities from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 13), one small value ($\sim -10^{-19}$) differs in the first digit after the decimal, 752 differ in the third digit, 13,898 differ in the fourth, 5600 differ in the fifth, and 2646 differ in the sixth. This is out of 45,630 non-zero values compared. This comparison required summing the appropriate `redoin/lnk3dnt` sensitivities to match the fine meshes with the corresponding coarse meshes on Figure 1. This sum was done with numbers printed with six digits after the decimal, and this limited precision is probably what leads to the large number of differences.

Comparing the k_{eff} surface derivatives for the material interfaces and outer boundary from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 13), three values differ in the sixth digit after the decimal. This is out of 60 non-zero values compared.

Comparing the reaction-rate ratio mass density sensitivities from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 14), two small values ($\sim \pm 10^{-12}$) differ in the second digit after the decimal, 1438 differ in the third digit, 27,164 differ in the fourth digit, 11,926 differ in the fifth digit, and 5112 differ in the sixth digit. This is out of 91,260 non-zero values compared. This comparison required summing the appropriate `redoin/lnk3dnt` sensitivities to match the fine meshes with the corresponding coarse meshes on Figure 1. This sum was done with numbers printed with six digits after the decimal, and this limited precision is probably what leads to the large number of differences.

Comparing the reaction-rate ratio surface derivatives for the material interfaces and outer boundary from the finely-discretized SENSMG input and the `redoin/lnk3dnt` input (step 14), two values differ in the sixth digit after the decimal. This is out of 120 non-zero values compared.

III. Summary and Future Work

The SENSMG multigroup neutron sensitivity code can read materials and geometry from `redoin` and `lnk3dnt` files. These may be written by PARTISN or MCNP6 (these codes write `lnk3dnt` files as standard features[3,4]) or by any code as long as the format (as defined in Chapter 11 of the PARTISN manual[3]) is correct. Note that a `lnk3dnt` file is useless on its own; it always needs an associated `redoin` file. This report verified that the capability works when transport correction is used.

The capability does not yet work with fixed-source problems. The difficulty is that, in general, a `lnk3dnt` mesh mixes adjacent materials, and the resulting material will have the same isotope replicated for each material in which it appears. The ideal way to handle this would be to keep the material definition with replicated isotopes and keep track of the contribution to each material that they came from. However, the codes that SENSMG uses to compute intrinsic neutron sources, MISC (Ref. 11) and SOURCES4C (Ref. 12), cannot yet handle replicated isotopes in a material. We are considering how to handle this issue.

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JAF:jaf

Distribution:
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J. A. Dahl, CCS-2, MS D409, dahl@lanl.gov
E. J. Davis, CCS-2, MS D409, ejdavis@lanl.gov
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W. Haeck, XCP-5, MS P365, wim@lanl.gov
D. Neudecker, XCP-5, MS P365, dneudecker@lanl.gov
D. K. Parsons, XCP-5, MS F663, dkp@lanl.gov
P. Talou, XCP-5, MS F644, talou@lanl.gov
J. L. Alwin, XCP-7, MS A143, jalwin@lanl.gov
A. Sood, XCP-7, MS F663, sooda@lanl.gov
J. A. Favorite, XCP-7, MS F663, fave@lanl.gov
National Security Research Center, nsrc-cataloging@lanl.gov
XCP-7 File

APPENDIX
INPUT FILES FOR THE TEST PROBLEM

Original SENSMG Input for Test 1 and Test 3

```
simple BeRP ball, 38.1 mm reflector, no steel or NO
sphere keff
mt80
2 / no of materials
1 94239 -9.38039E-01 94240 -5.94112E-02 31069 -1.51515E-03 31071 -1.03465E-03 / simple BeRP
2  6000 -8.56299E-01 1001 -1.43701E-01 / HDPE, C2H4
-19.6 -0.95 / densities
2 / no of shells
 3.794  7.604  / radii
 1    2       / material nos
 1           / number of edit points
 1
 2           / number of reaction-rate ratios
 94239 16   /
 31069  6  94239 16   /
 0           / number of njoy reactions
```

REDOIN Input File for Test 1
This file is not a valid PARTISN input, but it is a valid SENSMG input.

```
     3     0     0     1     0
simple BeRP ball, 38.1 mm reflector, no steel or NO
input: berp_simp
 forward input file, keff

&block_1
   b1_inputs=8
   niso=0
   it=1521
   mt=4
   im=2
   isn=32
   nzone=2
   ngroup=30
   igeom="sphere"
/

&block_2
/
&block_2_arrays
/

&block_3
   b3_inputs=6
   libname="mt80"
   fissdata=0
   lib="ndilib"
   fissneut=1
   lng=30
   ebound_size=31
/
&block_3_arrays
   ebound=
      1.700000E+01  1.500000E+01  1.350000E+01  1.200000E+01  1.000000E+01  7.790000E+00  6.070000E+00
3.680000E+00  2.865000E+00  2.232000E+00
      1.738000E+00  1.353000E+00  8.230000E-01  5.000000E-01  3.030000E-01  1.840000E-01  6.760000E-02
2.480000E-02  9.120000E-03  3.350000E-03
      1.235000E-03  4.540000E-04  1.670000E-04  6.140000E-05  2.260000E-05  8.320000E-06  3.060000E-06
1.130000E-06  4.140000E-07  1.520000E-07
      1.390000E-10
/

&block_3_xsec
/
```

```
&block_4
   b4_inputs=3
   matspec_size=4
   matls_size=8
   assign_size=2
/
&block_4_arrays
   matspec=
      "wtfrac"
      "wtfrac"
      "atdens"
      "atdens"
   matls=
      "m000001" "94239.801nm" 9.3803900E-01
      "m000001" "94240.801nm" 5.9411200E-02
      "m000001" "31069.801nm" 1.5151500E-03
      "m000001" "31071.801nm" 1.0346500E-03
      "m000002" "6000.801nm" 8.5629900E-01
      "m000002" "1001.801nm" 1.4370100E-01
      "m000003" "94239.801nm" 1.
      "m000004" "31069.801nm" 1.
   assign=
      "zn000001" "m000001" 19.60000000
      "zn000002" "m000002" 0.95000000
/

&block_5_int
   b5_inputs=17
   nofxup=1
   npeg=2
   ith=0
   cellsol=0
   raflux=1
   ievt=1
   rmflux=1
   xsectp=2
   oitm=9999
   balp=1
/
&block_5_real
   epsi=1.00E-03
   extras=
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  1  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
   norm=1.0
/
&block_5_char
   trcor="diag"
/
&block_5_sizes
   isct_size=1
   iitl_size=1
   iitm_size=1
/
&block_5_arrays
   isct=
      1
   iitl=
      0
   iitm=
      999
/

&block_6
```

```
   b6_inputs=7
   igrped=0
   zned=1
   ajed=0
   edmats_size=2
   rsfnam_size=1
   edxs_size=20
   rsfe_size=30
/  nrrr=2
   points_size=1
/
&block_6_arrays
   edisos=
      "94239"
      "31069" "94239"
   edxs=
      "16"
       "6" "16"
   points=
1
   rsfnam=
      "flux"
   rsfe=
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
/
```

MCNP6.2 Input File for Test 2

```
simple BeRP ball, 38.1 mm reflector, no steel or NO
1   1    -19.6     -11                          imp:n=1
2   2    -0.95     -12 11                       imp:n=1
90  0              -99 12                       imp:n=1
99  0               99                          imp:n=0

11  so   3.794
12  so   7.604
99  so 100.

mode n
mesh  geom=sphere origin=0. 0. 0.
      ref=0. 0. 0.
      imesh= 7.604               iints=10
      jmesh= 0.5                 jints=1
      kmesh= 1.                  kints=1
dawwg points=10
      block=1 isn=32 ngroup=30 fmmix=1
      block=3 libname=mt80 fissneut=1
      block=5 ievt=1 trcor=diag diffsol=mg
              isct=1 epsi= 1.00E-03 norm=1.0 rmflux=1 oitm=9999 iitm=999
c             nofxup=1 iitl=0
sdef
m1    94239 -9.38039E-01
      94240 -5.94112E-02
      31069 -1.51515E-03
      31071 -1.03465E-03
m2     6000 -8.56299E-01
       1001 -1.43701E-01
c
print -30
```

PARTISN Input File for Test 2

```
     5     0     0     0     0
simple BeRP ball, 38.1 mm reflector, no steel or NO
*****************************************************
* Input autogenerated by MCNP                       *
* Input for PARTISN kcode run for comparison to MCNP  *
*****************************************************
```

```
/ *****************************************
/ Block I ... Dimensions and Controls ...
    igeom= sph
    nzone=       2
       im=      10
       it=      10
       jm=       1
       jt=       1
       km=       1
       kt=       1
   ngroup=      30
      isn=      32
     niso=       0
       mt=       4
    iquad=       1
    fmmix=       1
 t
/ *****************************************
/ Block III ... Nuclear Data Type and Options ...
 fissneut=       1
 fissdata=0 / fission transfer matrix
      lib= ndilib
  libname= mt80
 t
/ *****************************************
/ Block IV   ... Cross-Section Mixing ...
 matspec=wtfrac
         wtfrac
         atdens
         atdens
 matls=
        m000001
            "94239.801nm"  9.3803900E-01
            "94240.801nm"  5.9411200E-02
            "31069.801nm"  1.5151500E-03
            "31071.801nm"  1.0346500E-03;
        m000002
             "6000.801nm"  8.5629900E-01
             "1001.801nm"  1.4370100E-01;
/ edit isotopes
        m000003  "94239.801nm"  1.;
        m000004  "31069.801nm"  1.;
 assign=
        zn000001   m000001    1.00000000;
        zn000002   m000002    1.00000000;
 t
/ *****************************************
/ Block V ... Solver Input ...
     norm= 1.000E+00
     epsi= 1.000E-03
     ievt=       1
     isct=       1
     oitm=    9999
   rmflux=       1
     iitm=     999
    trcor= diag
   srcacc= dsa
  diffsol= mg
  nofxup=1 iitl=0
 t
/ *****************************************
/ Block VI ... Edit Controls ...
   massed=       1
   edoutf=       3
 t
/ *****************************************
```

REDOIN Input File for Test 2
This file is not a valid PARTISN input, but it is a valid SENSMG input.

```
     5     0     0     1     0
simple BeRP ball, 38.1 mm reflector, no steel or NO
```

```
******************************************************
* Input autogenerated by MCNP                        *
* Input for PARTISN kcode run for comparison to MCNP  *
******************************************************

&block_1
   b1_inputs=14
   iquad=1
   niso=0
   mt=4
   jt=1
   it=10
   km=1
   jm=1
   fmmix=1
   im=10
   isn=32
   ngroup=30
   kt=1
   nzone=2
   igeom="sph"
/

&block_2
   b2_inputs=0
/
&block_2_arrays
/

&block_3
   b3_inputs=4
   fissneut=1
   libname="mt80"
   fissdata=0
   lib="ndilib"
/
&block_3_arrays
/

&block_3_xsec
/

&block_4
   b4_inputs=3
   matspec_size=4
   matls_size=8
   assign_size=2
/
&block_4_arrays
   matspec=
      "wtfrac"
      "wtfrac"
      "atdens"
      "atdens"
   matls=
      "m000001" "94239.801nm" 9.3803900E-01
      "m000001" "94240.801nm" 5.9411200E-02
      "m000001" "31069.801nm" 1.5151500E-03
      "m000001" "31071.801nm" 1.0346500E-03
      "m000002" "6000.801nm" 8.5629900E-01
      "m000002" "1001.801nm" 1.4370100E-01
      "m000003" "94239.801nm" 1.
      "m000004" "31069.801nm" 1.
   assign=
      "zn000001" "m000001" 1.00000000
      "zn000002" "m000002" 1.00000000
/

&block_5_int
   b5_inputs=12
   oitm=9999
   nofxup=1
   rmflux=1
   ievt=1
```

```
/
&block_5_real
   epsi=1.000E-03
   norm=1.000E+00
/
&block_5_char
   diffsol="mg"
   trcor="diag"
   srcacc="dsa"
/
&block_5_sizes
   isct_size=1
   iitl_size=1
   iitm_size=1
/
&block_5_arrays
   isct=
      1
   iitl=
      0
   iitm=
      999
/

&block_6
   b6_inputs=2
   edoutf=3
   massed=1
/  nrrr=2
   points_size=5
/
&block_6_arrays
   edisos=
      "94239"
      "31069" "94239"
   edxs=
      "16"
       "6" "16"
   points=
1 2 3 4 5
/
```

Regular SENSMG Input File for Test 2

```
simple BeRP ball, 38.1 mm reflector, no steel or NO
sphere keff
mt80
    10 / no. of materials
     1   94239 -9.38039000E-01   94240 -5.94112000E-02   31069 -1.51515000E-03   31071 -1.03465000E-03 /
     2   94239 -9.38039000E-01   94240 -5.94112000E-02   31069 -1.51515000E-03   31071 -1.03465000E-03 /
     3   94239 -9.38039000E-01   94240 -5.94112000E-02   31069 -1.51515000E-03   31071 -1.03465000E-03 /
     4   94239 -9.38039000E-01   94240 -5.94112000E-02   31069 -1.51515000E-03   31071 -1.03465000E-03 /
     5   94239 -9.37579970E-01   94240 -5.93821271E-02   31069 -1.51440856E-03   31071 -1.03414369E-03
6000 -4.19030082E-04    1001 -7.03201123E-05 /
     6    6000 -8.56299000E-01    1001 -1.43701000E-01 /
     7    6000 -8.56299000E-01    1001 -1.43701000E-01 /
     8    6000 -8.56299000E-01    1001 -1.43701000E-01 /
     9    6000 -8.56299000E-01    1001 -1.43701000E-01 /
    10    6000 -8.56299000E-01    1001 -1.43701000E-01 /
 -1.96000000E+01 -1.96000000E+01 -1.96000000E+01 -1.96000000E+01 -1.94135000E+01 -9.50000000E-01 -
9.50000000E-01 -9.50000000E-01 -9.50000000E-01 -9.50000000E-01
    10 / no. of regions
  7.604000E-01  1.520800E+00  2.281200E+00  3.041600E+00  3.802000E+00  4.562400E+00  5.322800E+00
6.083200E+00  6.843600E+00  7.604000E+00
     1     2     3     4     5     6     7     8     9    10
     5 / number of edit points
     1     2     3     4     5
     2 / number of reaction-rate ratios
   94239  16            /
   31069   6   94239  16 /
     0 / number of njoy reactions
```

REDOIN Input File for Test 3
This file is not a valid PARTISN input, but it is a valid SENSMG input.

```
     3     0     0     1     0
simple BeRP ball, 38.1 mm reflector, no steel or NO
input: berp_simp
 forward input file, keff

&block_1
   b1_inputs=9
   niso=0
   maxscm=800000000
   it=1521
   mt=8
   im=1521
   isn=32
   nzone=8
   ngroup=30
   igeom="sphere"
/

&block_2
/
&block_2_arrays
/

&block_3
   b3_inputs=6
   libname="mt80"
   fissdata=0
   lib="ndilib"
   fissneut=1
   lng=30
   ebound_size=31
/
&block_3_arrays
   ebound=
      1.700000E+01  1.500000E+01  1.350000E+01  1.200000E+01  1.000000E+01  7.790000E+00  6.070000E+00
3.680000E+00  2.865000E+00  2.232000E+00
      1.738000E+00  1.353000E+00  8.230000E-01  5.000000E-01  3.030000E-01  1.840000E-01  6.760000E-02
2.480000E-02  9.120000E-03  3.350000E-03
      1.235000E-03  4.540000E-04  1.670000E-04  6.140000E-05  2.260000E-05  8.320000E-06  3.060000E-06
1.130000E-06  4.140000E-07  1.520000E-07
      1.390000E-10
/

&block_3_xsec
/

&block_4
   b4_inputs=3
   matspec_size=4
   matls_size=8
   assign_size=2
/
&block_4_arrays
   matspec=
      "atdens"
   assign=
      "matls"
   matls=
      "m000001" "94239.801nm" 1.
      "m000002" "94240.801nm" 1.
      "m000003" "31069.801nm" 1.
      "m000004" "31071.801nm" 1.
      "m000005" "6000.801nm" 1.
      "m000006" "1001.801nm" 1.
      "m000007" "94239.801nm" 1.
      "m000008" "31069.801nm" 1.
/

&block_5_int
```

```
   b5_inputs=17
   nofxup=1
   npeg=2
   ith=0
   cellsol=0
   raflux=1
   ievt=1
   rmflux=1
   xsectp=2
   oitm=9999
   balp=1
/
&block_5_real
   epsi=1.00E-03
   extras=
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  1  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
      0  0  0  0  0  0  0  0  0  0
   norm=1.0
/
&block_5_char
   trcor="diag"
/
&block_5_sizes
   isct_size=1
   iitl_size=1
   iitm_size=1
/
&block_5_arrays
   isct=
      1
   iitl=
      0
   iitm=
      999
/

&block_6
   b6_inputs=7
   igrped=0
   zned=1
   ajed=0
   edmats_size=2
   rsfnam_size=1
   edxs_size=20
   rsfe_size=30
/  nrrr=2
   points_size=759
/
&block_6_arrays
   edisos=
      "94239"
      "31069" "94239"
   edxs=
      "16"
       "6" "16"
   points=
001 002 003 004 005 006 007 008 009 010 011 012 013 014 015 016 017 018 019 020
021 022 023 024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040
041 042 043 044 045 046 047 048 049 050 051 052 053 054 055 056 057 058 059 060
061 062 063 064 065 066 067 068 069 070 071 072 073 074 075 076 077 078 079 080
081 082 083 084 085 086 087 088 089 090 091 092 093 094 095 096 097 098 099 100
101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
```

```
181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520
521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540
541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560
561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580
581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600
601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620
621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640
641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660
661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680
681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700
701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720
721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740
741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759
   rsfnam=
      "flux"
   rsfe=
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
      1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
/
```